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[TITLE OF THE INVENTION]	LIQUID CRYSTAL DISPLAY DEVICE AND MANUFACTURING METHOD THEREFOR
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【NAME OF DOCUMENT】 SPECIFICATION

【TITLE OF INVENTION】 LIQUID CRYSTAL DISPLAY DEVICE AND MANUFACTURING METHOD THEREFOR

【CLAIMS】

【CLAIM 1】 A liquid crystal display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of said liquid crystal layer, the liquid crystal layer and pair of electrodes being sandwiched by a pair of substrates, wherein:

the liquid crystal layer has a section obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface.

【CLAIM 2】 The liquid crystal display device according to claim 1, wherein the liquid crystal layer has a section obtained by polymerization through selective irradiation of active energy rays followed by irradiation of active energy rays all over the substrate surface with voltage application.

【CLAIM 3】 The liquid crystal display device according to claim 2, wherein at least one of the two irradiations of active energy rays has been carried out along a direction tilted from the normal to the substrate surface.

【CLAIM 4】 The liquid crystal display device according to either of claims 1 to 3, wherein the liquid crystal layer shows a specific light shielding pattern caused by the alignment of liquid crystal molecules when a voltage is applied after the irradiation or irradiations of active energy rays.

【CLAIM 5】 A method for manufacturing a liquid crystal display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being installed between a pair of substrates, the method comprising:

forming the liquid crystal layer from a liquid crystal composition comprising a liquid crystal and a polymerizable compound;

polymerizing part of the polymerizable compound by selective irradiation of active energy rays over the substrate surface with no voltage application; and then,

polymerizing the polymerizable compound by irradiation of active energy rays all over the substrate surface with voltage application.

【DETAILED EXPLANATION OF THE INVENTION】

【0001】

【TECHNICAL FIELD OF THIS INVENTION】

The present invention relates to a liquid crystal display device which can realize high transmission, high-speed response, and a wide viewing angle.

【0002】

【RELATED ART】

Recently, liquid crystal display devices have been widely used in various applications, taking advantage of features including flatness, light weight, low voltage driving and low electric power consumption. Furthermore, display characteristics

which can compete with those of CRTs have been realized, and accordingly, liquid crystal display devices are used even for applications such as monitors and television sets for which CRTs have been mainly used conventionally.

【0003】

Among the liquid crystal display devices which have been used in practice as having high display characteristics that can compete with those of CRTs, known are MVA (multi-domain vertical alignment) mode liquid crystal display devices. In the MVA mode liquid crystal display devices, the liquid crystal molecules are aligned vertically to the substrate surface when no voltage is applied, and when a voltage is applied, protrusions and depressions formed on a substrate surface, or slits installed in an electrode control the directions toward which the liquid crystal molecules tilt.

【0004】

Fig. 1 illustrates an example of a patterned pixel electrode structure in an MVA mode liquid crystal display device. This pixel electrode is composed of a crisscross basic region 1 and four branch regions 2 that extend linearly to the 45° , 135° , 225° and 315° directions. The branch regions have an electrode width of about 3 μm, and a slit width of about 3 μm. The electrode on the counter substrate (not illustrated) is a uniform electrode as a whole.

【0005】

When a voltage is applied to an electrode in which fine slits are formed as shown in Fig. 1, the liquid crystal molecules show a property of tilting along the directions of the slits. In the case of Fig. 1, when a voltage is applied, the liquid crystal

molecules 4 in the near-basic region 3 start to tilt along the directions of the slits as illustrated, and the behavior of the liquid crystal molecules is propagated to the liquid crystal molecules in the branch regions, sequentially making them tilt along the directions of the slits. As a result, the liquid crystal layer forms a pattern according to the pattern given by the electrode which is outside of the liquid crystal layer, and the alignments in the four domains are realized in which the liquid crystal molecules tilt toward the four respective directions in the four branch regions.

【0006】

However, when a voltage is applied, the behavior of the liquid crystal molecules in the near-basic region is propagated to the surrounding regions, and therefore, some time is needed for all the liquid crystal molecules to eventually tilt. In addition, if the branch regions are long, there are occasions, as shown in Fig. 1, in which liquid crystal molecules that should tilt toward the proper A direction actually tilt toward the B direction which is the reverse of the A direction, when they are in a branch part far away from the near-basic region. It is considered to be caused by the liquid crystal molecules tilting before the behavior of the liquid crystal molecules in the near-basic region is propagated to the surrounding regions. In this case, a bordering area is formed between A and B, and the bordering area does not transmit light even when a voltage is applied, and accordingly, cause the lowering of the transmittance.

【0007】

As a means to solve the above-described problem, a method is proposed in which a liquid crystal layer is formed in an MVA mode liquid crystal display device by sealing a liquid crystal composition comprising a liquid crystal and a polymerizable compound in the device, and the compound is polymerized by irradiating active energy rays over the substrate surface, while a voltage is applied to the liquid crystal layer to regulate the alignment (see patent documents 1 to 3, described later)

Taking, as an example, a case in which a liquid crystal composition comprising a liquid crystal and a polymerizable compound is sealed in an MVA mode liquid crystal display device having an electrode pattern as shown in Fig. 1, it is possible to prevent the liquid crystal molecules from tilting in the reverse directions as shown at B in Fig. 1, by gradually applying a voltage during the realization of the four domain alignments through voltage application as described above. Then, the compound is subjected to polymerization by irradiating active energy rays over the panel surface, in this state. Through this, the compound is polymerized, with the result that the tilting directions of the liquid crystal molecules are fixed in a state as a voltage is applied.

【0008】

The liquid crystal display device thus prepared has the liquid crystal molecules having some tilts toward the directions to which the molecules are to tilt as against the vertical direction, even when no voltage is applied. Therefore, the response speed at the time of voltage application is improved, and a uniform and stable alignment status is realized. In addition, since in the liquid

crystal display device of this mode, there is no need of forming protrusions or the like that cause the decrease in the transmittance, a liquid crystal display device with a high transmittance can be realized. That is, such an MVA mode liquid crystal display device can realize a high transmittance, high-speed response, and uniform and stable alignment status, compared with the conventional MVA mode liquid crystal display devices.

【0009】

However, in this mode, it is necessary to introduce a patterned electrode in order to regulate the tilting directions of the liquid crystal molecules, which may result in fluctuation in qualities, complicated processings, decrease in production yield, and high costs. Particularly when fine slits as shown in Fig. 1 are installed, the transmittance fluctuates even by a slight fluctuation of the patterning. Accordingly, a very high precision is required in the production process.

【0010】

【Patent document 1】

Japanese Unexamined Patent Application Publication No. H7-43689 (claims)

【0011】

【Patent document 2】

Japanese Unexamined Patent Application Publication No. H9-146068 (claims)

【0012】

【Patent document 3】

Japanese Unexamined Patent Application Publication No.

【0013】

【SUBJECTS SOLVED BY THIS INVENTION】

Accordingly, it is an object of the present invention to provide a liquid crystal display device excellent in high transmission, high-speed response, wide viewing angle, etc. It is also an object of the present invention to provide a method for manufacturing the liquid crystal display device. Other purposes and advantages of the present invention will be clarified in the following explanations.

【0014】

【MEANS FOR SOLVING THE SUBJECTS】

According to one aspect of the present invention, provided is a liquid crystal display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being sandwiched by a pair of substrates, wherein: the liquid crystal layer has a section obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface. It is preferable that the liquid crystal layer has a section obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface without voltage application.

By the present invention, a liquid crystal display device excellent in high transmission, high-speed response, wide viewing

angle, etc. can be obtained.

【0015】

According to another aspect of the present invention, provided is a method for manufacturing a liquid crystal display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being installed between a pair of substrates, the method comprising: forming the liquid crystal layer from a liquid crystal composition comprising a liquid crystal and a polymerizable compound; polymerizing part of the polymerizable compound by selective irradiation of active energy rays over the substrate surface with no voltage application; and then, polymerizing the polymerizable compound by irradiation of active energy rays all over the substrate surface with voltage application. According to the present invention, a simplified manufacturing process can be realized and causes of fluctuation in qualities, complicated processings, decre3ase in production yield, and high costs in the conventional methods can be eliminated.

【0016】

Preferable are that a photomask is used for the selective irradiation of active energy rays; that the light shielding section width and opening width of the photomask are each in the range of 2 to 100 μm; that at least one of the two irradiations of active energy rays has been carried out along a direction tilted from the normal to the substrate surface; that the liquid crystal layer shows a specific light shielding pattern caused by the

alignment of liquid crystal molecules when a voltage is applied after the irradiation or irradiations of active energy rays; that the specific light shielding pattern caused by the alignment of liquid crystal molecules includes at least one pattern selected from the group consisting of a lattice pattern, a crisscross pattern, a pattern in the shape of stripes and a pattern in the shape of stripes with bends; that the liquid crystal has a negative dielectric constant anisotropy, and is aligned in the direction vertical to the substrate surface when no voltage is applied after the irradiation or irradiations of active energy rays; that a first polarizer and a second polarizer are installed each on one of the outer sides of the pair of substrates so that the absorption axes of the two polarizers are perpendicular to each other; a first 1/4 wavelength plate is installed between one of the substrates and the first polarizer; a second 1/4 wavelength plate is installed between the other one of the substrates and the second polarizer; and, the absorption axis of the first polarizer is at 45° from the phase delay axis of the first 1/4 wavelength plate, the absorption axis of the second polarizer is at 45° from the phase delay axis of the second 1/4 wavelength plate, and the phase delay axis of the first 1/4 wavelength plate and the phase delay axis of the second 1/4 wavelength plate are perpendicular to each other.

【0017】

【EMBODIMENTS】

Embodiments according to the present invention will be described with reference to the following figures, examples, etc. It is to be understood that these figures, examples, etc., plus

the explanation below are for the purpose of illustrating the present invention, and do not limit the scope of the present invention. It goes without saying that other embodiments should also be included in the category of the present invention as long as they conform to the gist of the present invention. In the figures, the same sign indicates the same element.

【0018】

A liquid crystal display device according to the present invention comprises a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being sandwiched by a pair of substrates, wherein: the liquid crystal layer has a section obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface. In the following, this selective irradiation of active energy rays is called a selective active energy ray irradiation. It is convenient and reliable to use a so-called photomask in the selective active energy ray irradiation. It is to be noted that there is no particular limitation to the type of active energy rays for use. Ultraviolet rays are preferably used. In this case, other types of energy such as heat may be used together, as long as they do not contradict the gist of the present invention.

【0019】

The liquid crystal layer before irradiating the substrate surface with active energy rays is composed of a composition (a

liquid crystal composition) comprising a liquid crystal and a polymerizable compound, in which the liquid crystal and polymerizable compound are present together. However, when the polymerizable compound in the liquid layer is subjected to the selective polymerization as described above, sections which reflect the pattern of the light-exposed parts as the liquid crystal layer is seen in the direction vertical to the substrate surface, turn to be a polymerized liquid crystal composition, and the sections which reflect the pattern of the light-shielded parts remain as an unpolymerized liquid crystal composition.

【0020】

It is preferable to carry out the selective active energy ray irradiation in a state of no voltage application. By this, the polymerizable compound in the liquid crystal composition that has been subjected to the selective active energy ray irradiation is crosslinked (cured) in a state in which the liquid crystal is vertically aligned, thus contributing to the eventual alignment and orientations in the liquid crystal layer. It was found that if such a pattern owing to the polymerized liquid crystal composition is present in the liquid crystal composition, the liquid crystal molecules tend to show alignment tilted to the directions along or regulated by the pattern when the unpolymerized liquid crystal composition are subjected to polymerization afterward.

【0021】

Utilizing this makes it possible to regulate the directions of tilting of liquid crystal molecules in the areas outside of the pattern by the polymerized liquid crystal composition, even though

known techniques such as patterning of an electrode, installation of uneven parts and rubbing of alignment control films are not employed. It is to be noted here that the patterning of an electrode, installation of uneven portions, rubbing of alignment control films, or the like may be carried out in combination with this.

【0022】

It is possible to carry out the polymerization of the unpolymerized liquid crystal composition by irradiating active energy rays all over the substrate surface (overall active energy ray irradiation) with voltage application, after the selective active energy ray irradiation. The unpolymerized liquid crystal composition is thus polymerized, and the liquid crystal molecules show alignment as tilted in the directions along or regulated by the pattern of the polymerized liquid crystal composition.

【0023】

There is no particular limitation to the polymerizable compound, as long as it is a polymerizable compound. It may be a so-called monomer or oligomer. This polymerization is often crosslinking polymerization, but other types of polymerization are also applicable. The polymerizable compound may be a mixture of a plurality of compounds. If catalysts and other additives are necessary, they can be used as constituents of the liquid crystal composition.

【0024】

Whether the liquid crystal composition is polymerized, or whether a needed pattern is obtained may be determined by checking whether the liquid crystal molecules show alignment as tilted in

the directions along or regulated by a specific pattern, when the unpolymerized liquid crystal composition is polymerized afterwards. The "whether the liquid crystal molecules show alignment as tilted in the directions along or regulated by a specific pattern" may be determined by checking whether the liquid crystal layer shows a specific light shielding pattern owing to the alignment of the liquid crystal, when a voltage is applied after the irradiations of active energy rays.

【0025】

For example, in the case of a liquid crystal display device as one of preferred embodiments of the present invention having a structure wherein a first polarizer and a second polarizer are installed each on one of the outer sides of the pair of substrates so that the absorption axes of the two polarizers are perpendicular to each other, the liquid crystal layer has a liquid crystal having a negative dielectric constant anisotropy, and the liquid crystal is aligned in the direction vertical to the substrate surface when no voltage is applied , light does not transmit the liquid crystal display device owing to the second polarizer that shields the light which transmits the first polarizer, when no voltage is applied. This is because the liquid crystal is aligned vertically to the substrate surface. However, when a voltage is applied, birefringence occurs where the liquid crystal molecules are aligned as tilted in appropriate directions to the substrate surface, allowing transmittance of light.

【0026】

In this occasion, in the areas that are polymerized by the

overall active energy ray irradiation, the liquid crystal molecules show alignment as tilted in the directions along or regulated by the pattern owing to the above-described polymerized liquid crystal composition. Accordingly, if the pattern owing to the above-described polymerized liquid crystal composition is appropriate, the sections in which the liquid crystal molecules are aligned as tilted in the appropriate directions transmit light, while areas in which the tilting angles of the liquid crystal molecules are different from each other, are present in a random manner in the areas polymerized by the selective active energy ray irradiation, when there is no pattern present to be aligned along, and do not allow light transmission. In this way, a pattern that does not transmit light (a light shielding pattern in the liquid crystal layer owing to the alignment of the liquid crystal) occurs in the areas corresponding to the selective active energy ray irradiation and part of areas corresponding to the overall active energy ray irradiation.

【0027】

The voltage application conditions for generating the a light shielding pattern in the liquid crystal layer owing to such alignment of a liquid crystal are determined by the factors whether the liquid crystal has a negative dielectric constant anisotropy or a positive dielectric constant anisotropy, whether the alignment control film is a vertical alignment control film or horizontal alignment control film, etc. For example, if the liquid crystal has a negative dielectric constant anisotropy, and the alignment control film is a vertical alignment control film, the light

shielding pattern in the liquid crystal layer will occur by the alignment of the liquid crystal when a voltage is applied as described above. In this specification, for the purpose of simplification, the explanation will be made, unless otherwise noted, on the preferred cases in which the liquid crystal has a negative dielectric constant anisotropy, and is aligned in the direction vertical to the substrate surface by installing a vertical alignment control film or the like, when no voltage is applied.

【0028】

When a liquid crystal display device is prepared with a liquid crystal layer 23 and a pair of electrodes on both sides of the liquid crystal layer (not shown) installed between a pair of substrates 21, 22, such an active energy ray irradiation treatment can be carried out, as shown in Fig. 2 for example, by sealing a liquid crystal composition comprising a liquid crystal and a polymerizable compound between the substrates to form the liquid crystal layer; polymerizing part of the polymerizable compound by selective irradiation of active energy rays over the substrate surface with no voltage application; and then, polymerizing the polymerizable compound by irradiation of active energy rays all over the substrate surface with voltage application as shown in 2(B) of Fig. 2.

【0029】

By the present invention, causes for fluctuation in qualities, complicated processings, decrease in production yield, and high costs due to the electrode pattern having a fine width can be eliminated by such a simple manufacturing process.

【0030】

Ultraviolet rays are convenient as the active energy rays, and are preferable. It is convenient and effective to carry out the selective active energy ray irradiation, for example, via a photomask 24.

【0031】

For example, active energy rays are irradiated selectively over the substrate surface through the photomask 24 having light shielding sections 31 and openings 32 as shown in 3(A) of Fig. 3, in the state of no voltage applied onto the liquid crystal layer. In this state, the compound is polymerized in areas corresponding to the openings 32 of the photomask as shown in 3(B) of Fig. 3, forming the polymerized liquid crystal composition areas 33.

【0032】

Afterwards, when voltage is applied, the polymerized liquid crystal composition areas 33 gives a state in which the liquid crystal molecules are hard to tilt, compared with areas located under the light shielding sections of the photomask, that is, the unpolymerized liquid crystal composition areas 34. Furthermore, as shown in 3(C) of Fig. 3, the liquid crystal molecules 4 in the areas where the compound is not polymerized become to tilt roughly symmetrical about the centers of the light shielding sections. The overall active energy ray irradiation is carried out in this state to polymerize the compound.

【0033】

4(B) of Fig. 4 shows a state of alignment when voltage was actually applied to the liquid crystal of a liquid crystal display device prepared according to the present invention, using the

photomask shown in 4(A) of Fig. 4. It is to be noted that the first and second polarizers were placed on either side of the liquid crystal display device respectively with their absorption axes perpendicular to each other. In 4(B) of Fig. 4, the areas 41 that appear black correspond to the light shielding pattern in the liquid crystal layer owing to the alignment of the liquid crystal molecules that was described previously.

【0034】

Various variations are possible as a photomask pattern, and can be appropriately selected depending on purposes. For example, preferable embodiments are masks having lattice patterns as shown in Fig. 5 which can result in light shielding patterns in the liquid crystal layers caused by the alignment of the liquid crystal molecules that are similar to the lattice patterns.

【0035】

A mask is also a preferable embodiment which has been used as an electrode pattern in the conventional MVA mode liquid crystal display devices, and which has, as shown in Fig. 6, a fine slit pattern with a crisscross basic region and branch regions extending linearly to the peripheral directions so that it can make the light shielding pattern in the liquid crystal layer by the alignment of liquid crystal molecules contain a crisscross pattern. In Figs. 5 and 6, the dark parts are the light shielding sections, and the light parts are the openings.

【0036】

When the active energy rays are ultraviolet rays, the intensity of the selective active energy ray irradiation is

preferably in the range of 0.5 to 10 J/cm². The intensity of the overall active energy ray irradiation is preferably in the range of 2 to 40 J/cm². Thus, alignment towards specific tilted directions can be realized swiftly and precisely.

【0037】

The width of the light shielding sections and width of openings of a photomask are preferably in the range of 2 to 100 μm, respectively. Thus, it becomes easier to realize alignment tilted in appropriate directions according to the present invention.

【0038】

When active energy ray irradiation is carried out from a direction tilted to the normal of the substrate surface, liquid crystal molecules has a property to show tilting along the direction of the active energy ray irradiation. When the above-described active energy ray irradiation is carried out from a specific direction tilted to the normal of the substrate surface utilizing this, it is easier to regulate the tilting directions of the liquid crystal molecules, and accordingly sometimes preferable. The specific tilted directions may be arbitrarily set depending on practices. The active energy ray irradiation from the specific tilted direction may be applied to either of the selective active energy ray irradiation and the overall active energy ray irradiation.

【0039】

When such areas showing a decreased transmittance appear by active energy ray irradiation from a specific titled direction or

the like, the transmittance in the areas showing a decreased transmittance can be improved, as shown in Fig. 7, by installing a first 1/4 wavelength plate 72 between one of the substrates 21 and a first polarizer 71; installing a second 1/4 wavelength plate 74 between the other one of the substrates 22 and a second polarizer 73; making the absorption axis of the first polarizer 71 and the phase delay axis of the first 1/4 wavelength plate 72 placed at 45° from each other; making the absorption axis of the second polarizer 73 and the phase delay axis of the second 1/4 wavelength plate 74 placed at 45° from each other; and making the phase delay axis of the first 1/4 wavelength plate 72 and the phase delay axis of the second 1/4 wavelength plate 74 placed perpendicular to each other (Iwamoto, Togo, and Iimura, Preprints of Symposium on Japanese Liquid Crystal Society, 2000, PCa02, 2000), with the result that the transmittance can be improved as a whole. That is, by utilizing 1/4 wavelength plates, it is possible to improve the transmittance of areas having a low transmittance such as shown in the dark portions in 4(B) of Fig. 4.

【0040】

In the case of the configuration shown in Fig. 7, when I_{in} refers to an incident radiation intensity, I_{out} refers to the intensity of transmitted light, and R_{LC} refers to a retardation of a liquid crystal layer, the following relationship holds. That is, the intensity of transmitted light is determined only by R_{LC} and not dependent on the tilting directions of liquid crystal molecules.

【0041】

$$I_{out} = 1/2 I_{in} \sin^2 (R_{LC}/2)$$

In this way, it is possible to improve the transmittance of areas having a low transmittance such as shown in 4(B) of Fig. 4, by utilizing 1/4 wavelength plates in the present invention.

【0042】

There is no particular limitation to the polymerizable compound used for a liquid crystal composition according to the present invention, and any known polymerizable compound may be used that is used together with a liquid crystal in a liquid crystal display device. Crosslinking-polymerizable compounds are generally preferable. Diacrylate compounds are the examples.

There is no particular limitation also to the liquid crystal used for a liquid crystal composition according to the present invention, and any known liquid crystal may be used as long as it does not contradict the gist of the present invention. Nematic liquid crystals having a negative dielectric constant anisotropy are examples of a favorable liquid crystal, as has already been explained.

【0043】

In the way described above, the liquid crystal display devices according to the present invention can realize high transmission, high-speed response, and wide viewing angle properties that are on the same level as or higher than those of liquid crystal display devices by the conventional technologies with patterning of an electrode, installation of uneven portions, rubbing of alignment control films, or the like.

【0044】

Furthermore, according to the method for manufacturing a

liquid crystal display device of the present invention, a simplified manufacturing process can be realized, and the factors for fluctuation in qualities, complicated processings, decrease in production yield, and high costs can be eliminated.

【0045】

The liquid crystal display devices according to the present invention can be utilized, most typically, as liquid crystal display devices such as displays for personal computers and television receivers, by installing driving devices, etc. It goes without saying that they can be used for any other applications that need functions to control the way in which light is transmitted by the action of a liquid crystal. For example, liquid crystal shutters, liquid crystal projectors, photochromic glasses, and displays of mobile information terminals are enumerated.

【0046】

It goes without saying that the present invention is similarly effective even when horizontal alignment control films are used, or when liquid crystals having a positive dielectric constant anisotropy are used.

【0047】

The following are detailed explanations of embodiments according to the present invention.

【0048】

[EXAMPLE 1]

8(A) of Fig. 8 is a plan view illustrating a pixel structure in a liquid crystal display device according to the present invention. Gate bus lines 81 and data bus lines 82 are formed in

a matrix form, wherein a gate bus line 81 and a data bus line 82 are connected to a pixel electrode via a TFT element 83. In the central part of the pixel electrode, an auxiliary capacitor electrode 84 is formed. On the other substrate which is not illustrated, color filters, and a common electrode for all over the display area are formed (not illustrated).

【0049】

First, vertical alignment control films were formed on both substrates. Patterning of an electrode, installation of uneven portions, and rubbing of the alignment control films were not performed.

【0050】

Then, both substrates were stuck to each other with a spacer in between, and a liquid crystal composition obtained by mixing a nematic liquid crystal having a negative dielectric constant anisotropy and a diacrylate polymerizable compound at a concentration of 0.3 wt.% was sealed in the space to form a liquid crystal display device.

【0051】

Then, a photomask shown in 8(B) of Fig. 8 was overlaid to the liquid crystal display device as shown in 8(C) of Fig. 8, and 2 J/cm^2 of ultraviolet rays were selectively irradiated over the substrate surface through the photomask with no voltage application to the liquid crystal layer, to polymerize part of the polymerizable compound.

【0052】

Afterwards, the photomask was removed, and 4 J/cm^2 of

ultraviolet rays were irradiated all over the substrate surface with applying a voltage of 20 V to the liquid crystal layer so as to polymerize the polymerizable compound.

【0053】

Polarizers having absorption axes perpendicular to each other were placed on both sides of the liquid crystal display device, one layer of a 1/4 wavelength plate was placed between the liquid crystal display device and each polarizer, wherein the phase delay axis of a 1/4 wavelength plate and the absorption axis of an adjacent polarizer were made to be at 45° from each other, and both phase delay axes of the 1/4 wavelength plates were made to be perpendicular to each other.

【0054】

[EXAMPLE 2]

A liquid crystal display device was prepared in a similar manner as for EXAMPLE 1, except that the pixel structure shown in 9(A) of Fig. 9 was employed instead of the one shown in 8(A) of Fig. 8, the photomask shown in 9(B) of Fig. 9 was employed instead of the one shown in 8(B) of Fig. 8, and the layering as shown in 9(C) of Fig. 9 was employed instead of the one shown in 8(C) of Fig. 8.

【0055】

[EXAMPLE 3]

A liquid crystal display device was prepared in a similar manner as for EXAMPLE 1, except that the pixel structure shown in 10(A) of Fig. 10 was employed instead of the one shown in 8(A) of Fig. 8, the photomask shown in 10(B) of Fig. 10 was employed instead

of the one shown in 8(B) of Fig. 8, and the layering as shown in 10(C) of Fig. 10C was employed instead of the one shown in 8(C) of Fig. 8. The photomask shown in 10(B) of Fig. 10 had a light shielding section width of 3 μm and an opening width of 3 μm.

【0056】

As a result of the above-describe examples, the leading edge response speed/trailing edge response speed at the switching between white color and black color were 20 milliseconds to compare with the conventional value of 25 milliseconds, the total wave transmittance was 1.3 time larger, and the wide viewing angle properties were the same or higher in all cases, when compared with the conventional MVA mode employing patterning of an electrode. That is, liquid crystal display devices were realized that had high transmission, high-speed response, and wide viewing angle properties on the same level as or higher than those of liquid crystal display devices by the conventional technologies with patterning of an electrode, installation of uneven portions, rubbing of alignment control films, or the like.

【0057】

According to the above-disclosed explanation, the invention following additional notes will be installed.

【0058】

(Additional note 1) A liquid crystal display device including a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being sandwiched by a pair of substrates, wherein:

the liquid crystal layer has a section obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface.

【0059】

(Additional note 2) The liquid crystal display device according to the additional note 1, wherein the liquid crystal layer has a section obtained by polymerization through selective irradiation of active energy rays followed by irradiation of active energy rays all over the substrate surface with voltage application.

【0060】

(Additional note 3) The liquid crystal display device according to the additional note 2, wherein at least one of the two irradiations of active energy rays has been carried out along a direction tilted from the normal to the substrate surface.

【0061】

(Additional note 4) The liquid crystal display device according to either of the additional notes 1 to 3, where the liquid crystal layer shows a specific light shielding pattern caused by the alignment of liquid crystal molecules when a voltage is applied after the irradiation or irradiations of active energy rays.

【0062】

(Additional note 5) The liquid crystal display device according to the additional note 4, wherein the specific light shielding pattern caused by the alignment of liquid crystal molecules includes at least one pattern selected from the group consisting of a lattice pattern, a crisscross pattern, a pattern in the shape of stripes

and a pattern in the shape of stripes with bends.

【0063】

(Additional note 6) The liquid crystal display device according to either of the additional notes 1 to 5, wherein the liquid crystal has a negative dielectric constant anisotropy, and is aligned in the direction vertical to the substrate surface when no voltage is applied after the irradiation or irradiations of active energy rays.

【0064】

(Additional note 7) The liquid crystal display device according to either of the additional notes 1 to 6, wherein:

a first polarizer and a second polarizer are installed each on one of the outer sides of the pair of substrates so that the absorption axes of the two polarizers are perpendicular to each other;

a first 1/4 wavelength plate is installed between one of the substrates and the first polarizer;

a second 1/4 wavelength plate is installed between the other one of the substrates and the second polarizer; and,

the absorption axis of the first polarizer is at 45° from the phase delay axis of the first 1/4 wavelength plate, the absorption axis of the second polarizer is at 45° from the phase delay axis of the second 1/4 wavelength plate, and the phase delay axis of the first 1/4 wavelength plate and the phase delay axis of the second 1/4 wavelength plate are perpendicular to each other.

【0065】

(Additional note 8) A method for manufacturing a liquid crystal

display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being installed between a pair of substrates, the method comprising: forming the liquid crystal layer from a liquid crystal composition comprising a liquid crystal and a polymerizable compound; polymerizing part of the polymerizable compound by selective irradiation of active energy rays over the substrate surface with no voltage application; and then polymerizing the polymerizable compound by irradiation of active energy rays all over the substrate surface with voltage application.

【0066】

(Additional note 9) The method for manufacturing a liquid crystal display device according to the additional note 8, wherein a photomask is used for the selective irradiation of active energy rays.

【0067】

(Additional note 10) The method for manufacturing a liquid crystal display device according to the additional note 9, wherein the light shielding section width and opening width of the photomask are each in the range of 2 to 100 μm.

【0068】

(Additional note 11) The method for manufacturing a liquid crystal display device according to either of the additional notes 8 to 10, wherein the active energy rays are ultraviolet rays.

【0069】

(Additional note 12) The method for manufacturing a liquid crystal

display device according to either of the additional notes 8 to 11, wherein the irradiations of active energy rays are carried out so that the liquid crystal layer shows a specific light shielding pattern caused by the alignment of liquid crystal molecules when a voltage is applied after the irradiations of active energy rays.

【0070】

(Additional note 13) The method for manufacturing a liquid crystal display device according to either of the additional notes 8 to 12, wherein at least one of the two irradiations of active energy rays is carried out along a direction tilted from the normal to the substrate surface.

【0071】

【EFFECITIVENESS OF THIS INVENTION】

By the present invention, a liquid crystal display device excellent in high transmission, high-speed response, wide viewing angle, etc. can be obtained. The method for manufacturing a liquid crystal display device can be simplified.

【BRIEF DESCRIPTION OF DRAWINGS】

【FIG. 1】

This is a schematic plan view illustrating an example of a patterned pixel electrode structure in an MVA mode liquid crystal display device.

【FIG. 2】

2(A) and 2(B) of FIG. 2 are schematic views explaining an irradiation treatment of active energy rays.

【FIG. 3】

3(A) of FIG. 3 is a schematic plan view illustrating a

photomask, 3(B) of FIG.3 is a schematic plan view illustrating areas of a polymerized liquid crystal composition that correspond to the openings of the photomask, and 3(C) of FIG. 3 is a schematic plan view illustrating an alignment state of liquid crystal molecules when allover irradiation of active energy rays is carried out.

【FIG. 4】

4(A) of FIG.4 is a schematic plan view illustrating a photomask, and 4(B) of FIG. 4 is a schematic plan view illustrating an alignment state of a liquid crystal when voltage is applied on the liquid crystal in a liquid crystal display device that has been prepared.

【FIG. 5】

This is a schematic plan view illustrating photomask patterns.

【FIG. 6】

This is a schematic plan view illustrating another photomask pattern.

【FIG. 7】

This is a schematic view illustrating how polarizers and 1/4 wavelength plates are installed.

【FIG. 8】

8(A) of FIG. 8 is a schematic plan view illustrating a pixel structure in a liquid crystal display device used in an example according to the present invention. 8(B) of FIG. 8 is a schematic plan view illustrating a photomask used in an example according to the present invention. 8(C) of FIG. 8 is a schematic plan view

illustrating how a liquid crystal display device is overlaid with a photomask.

【FIG. 9】

9(A) of FIG. 9 is another schematic plan view illustrating a pixel structure in a liquid crystal display device used in an example according to the present invention. 9(B) of FIG. 9 is another schematic plan view illustrating a photomask used in an example according to the present invention. 9(C) of FIG. 9 is another schematic plan view illustrating how a liquid crystal display device is overlaid with a photomask.

【FIG.10】

10(A) of FIG. 10 is another schematic plan view illustrating a pixel structure in a liquid crystal display device used in an example according to the present invention. 10(B) of FIG. 10 is another schematic plan view illustrating a photomask used in an example according to the present invention. 10(C) of FIG. 10 is another schematic plan view illustrating how a liquid crystal display device is overlaid with a photomask.

【EXPLANATION OF SYMBOLS】

1	crisscross basic region
2	four branch regions
3	near-basic region
4	liquid crystal molecules
21, 22	substrates
23	liquid crystal layer
24	photomask
31	light shielding sections

32	openings
33	polymerized liquid crystal composition areas
34	unpolymerized liquid crystal composition areas
41	areas corresponding to the light shielding pattern in the liquid crystal layer owing to the alignment of the liquid crystal molecules
71	first polarizer
72	first 1/4 wavelength plate
73	second polarizer
74	second 1/4 wavelength plate
81	Gate bus lines
82	Data bus lines
83	TFT element
84	auxiliary capacitor electrode

【NAME OF DOCUMENT】 ABSTRACT

【ABSTRACT】

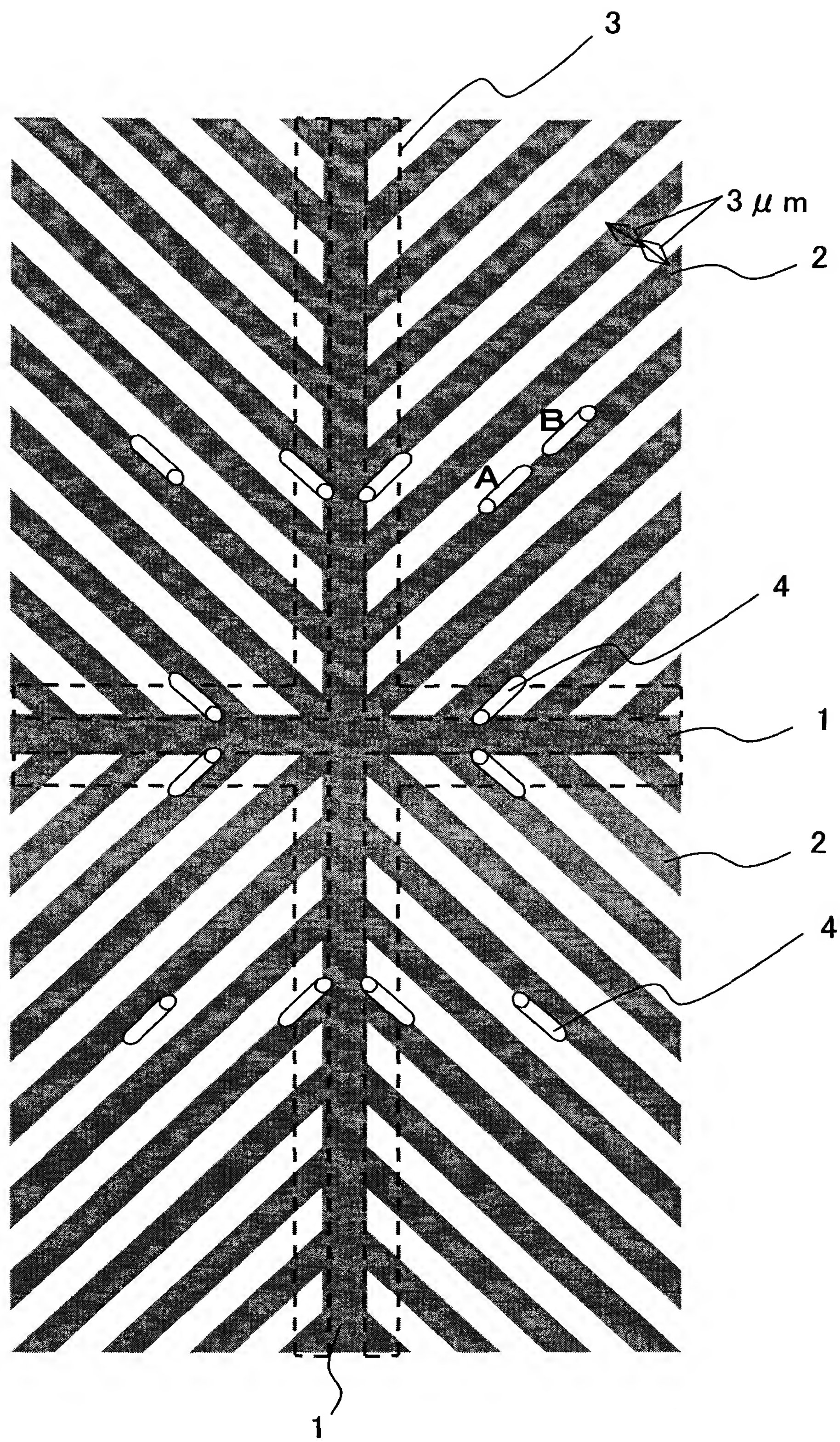
【SUBJECT】 To provide a liquid crystal display device which can realize high transmission, high-speed response, and a wide viewing angle.

【SOLVING MEANS】 In a liquid crystal display device comprising a liquid crystal layer and a pair of electrodes for applying voltage onto the liquid crystal installed on both sides of the liquid crystal layer, the liquid crystal layer and pair of electrodes being sandwiched between a pair of substrates, the liquid crystal layer is made to have sections obtained by polymerizing a polymerizable compound in the presence of the liquid crystal through selective irradiation of active energy rays over the substrate surface and a section obtained by polymerization through selective irradiation of active energy rays followed by irradiation of active energy rays all over the substrate surface with voltage application.

【SELECTED DRAWING】 NONE

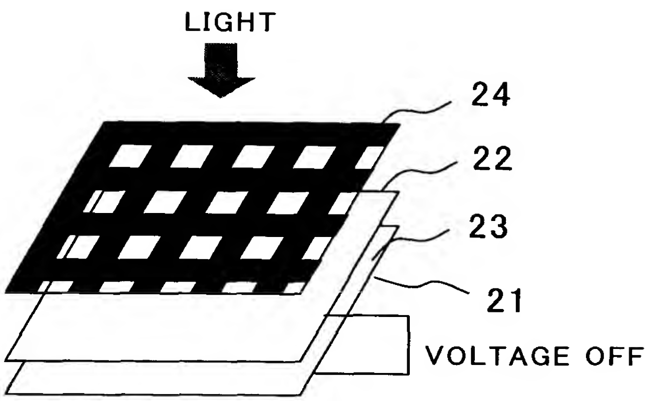
【NAME OF DOCUMENT】 DRAWINGS

【FIG. 1】

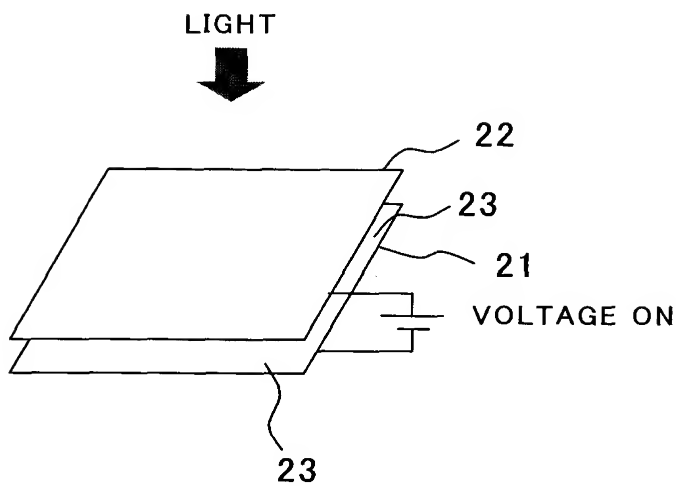


【FIG. 2】

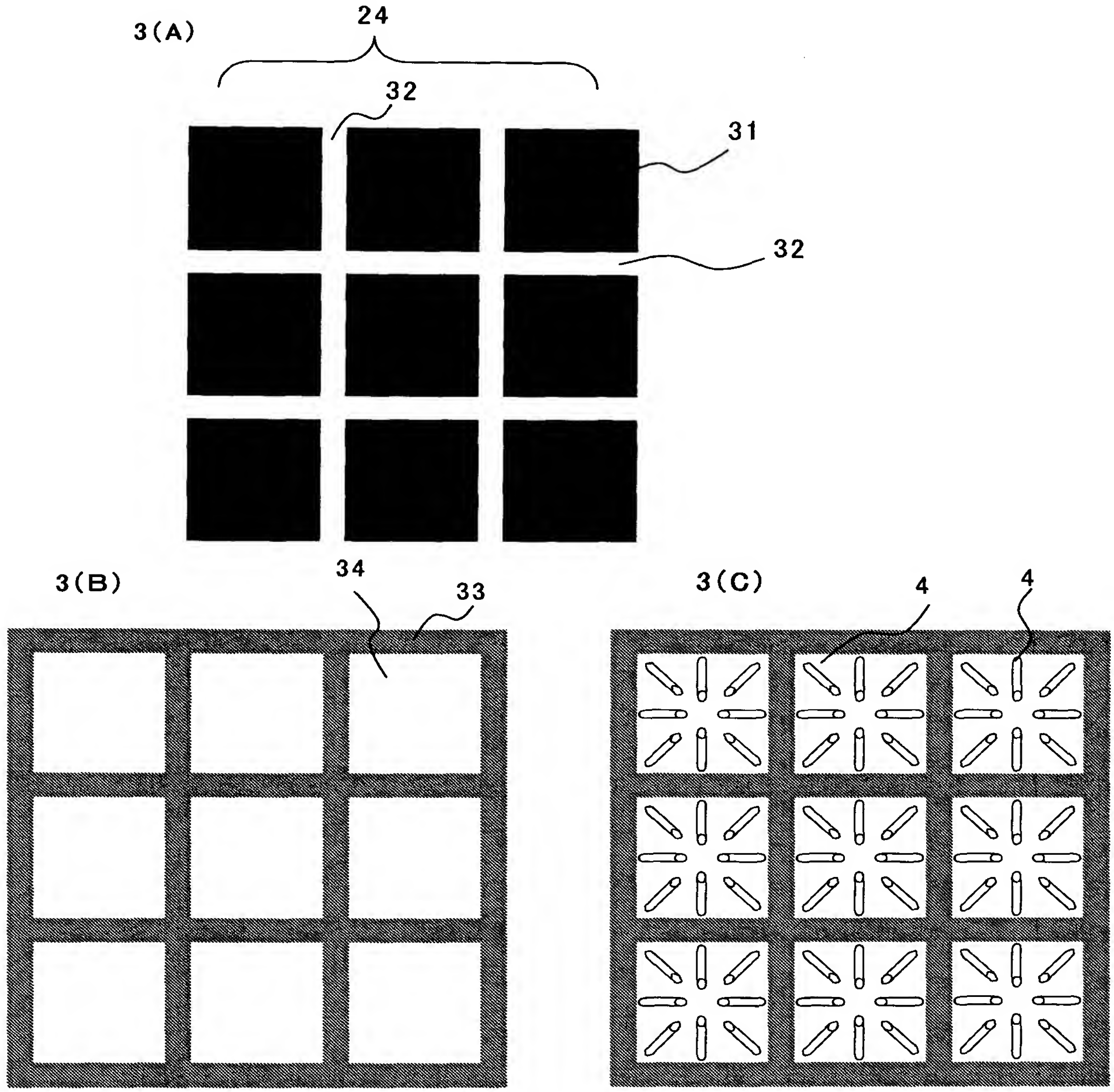
2(A)



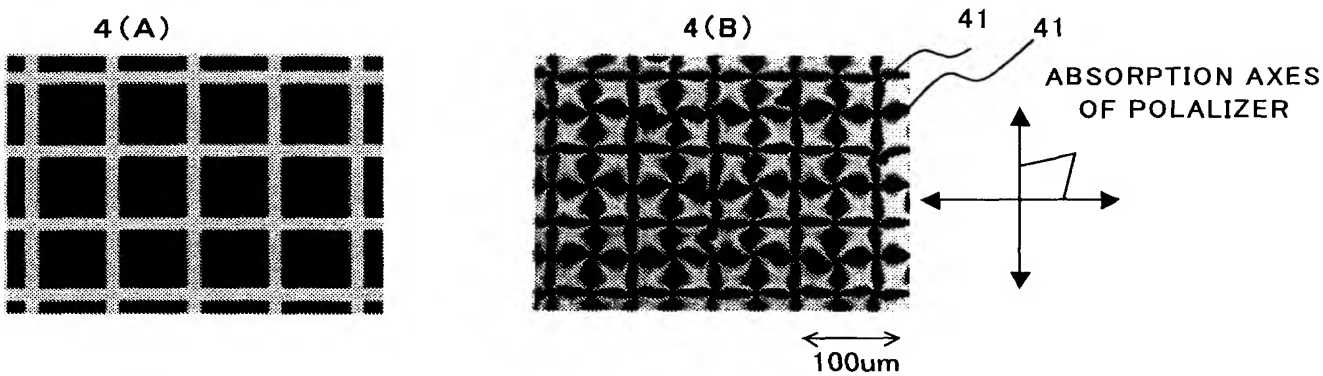
2(B)



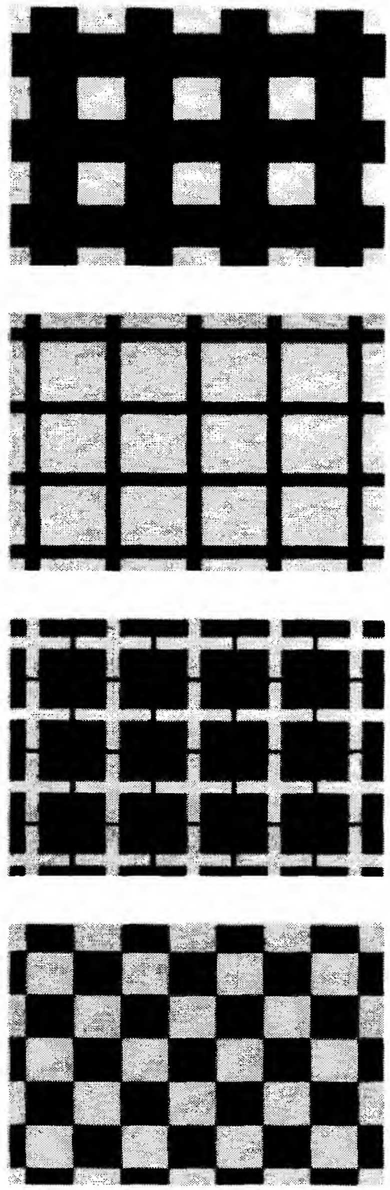
【FIG. 3】


3(A)
24
32
31
32
3(B)
34
33
3(C)
4
4

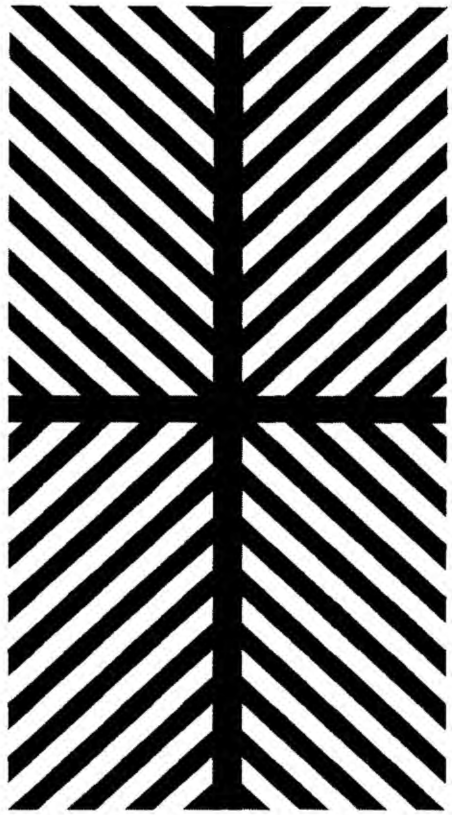
【FIG. 4】


4(A)
4(B)
41
41
ABSORPTION AXES OF POLALIZER
100um

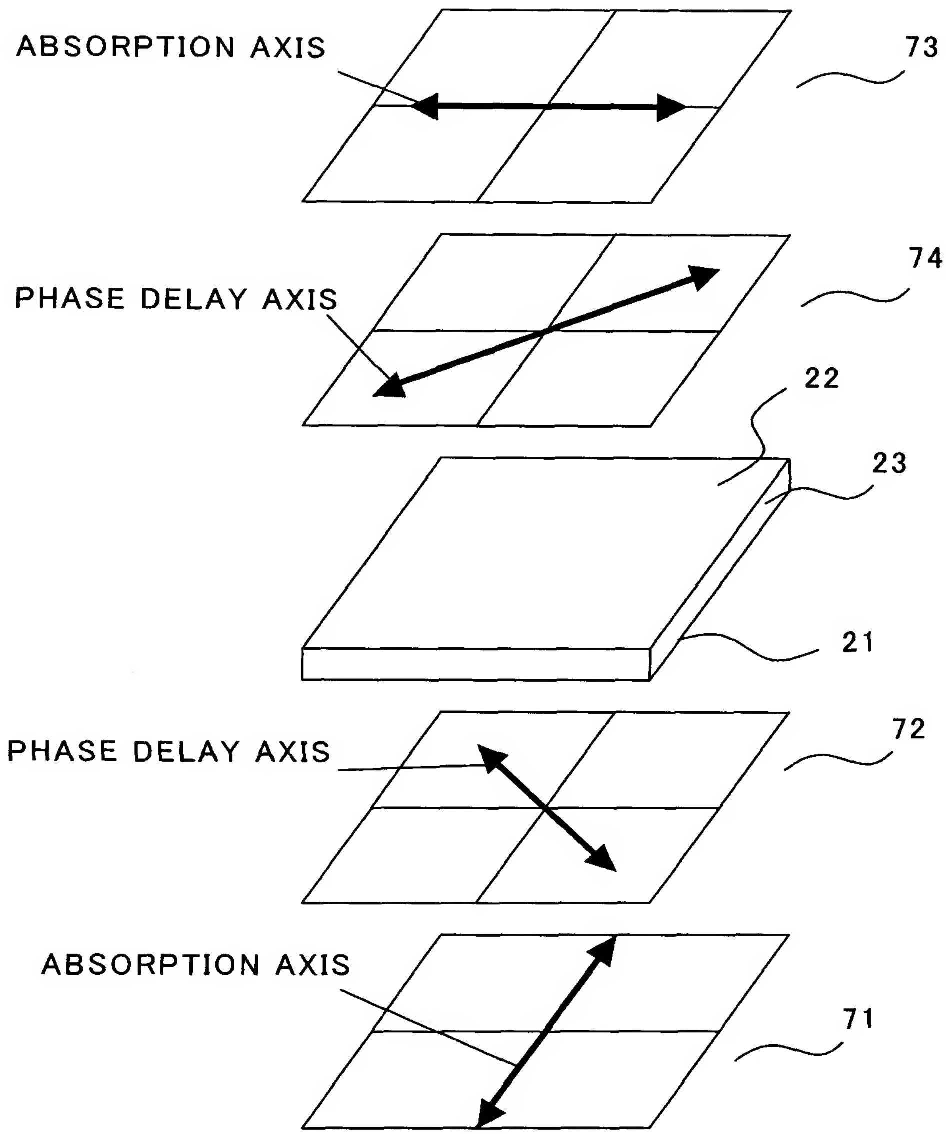
【FIG. 5】



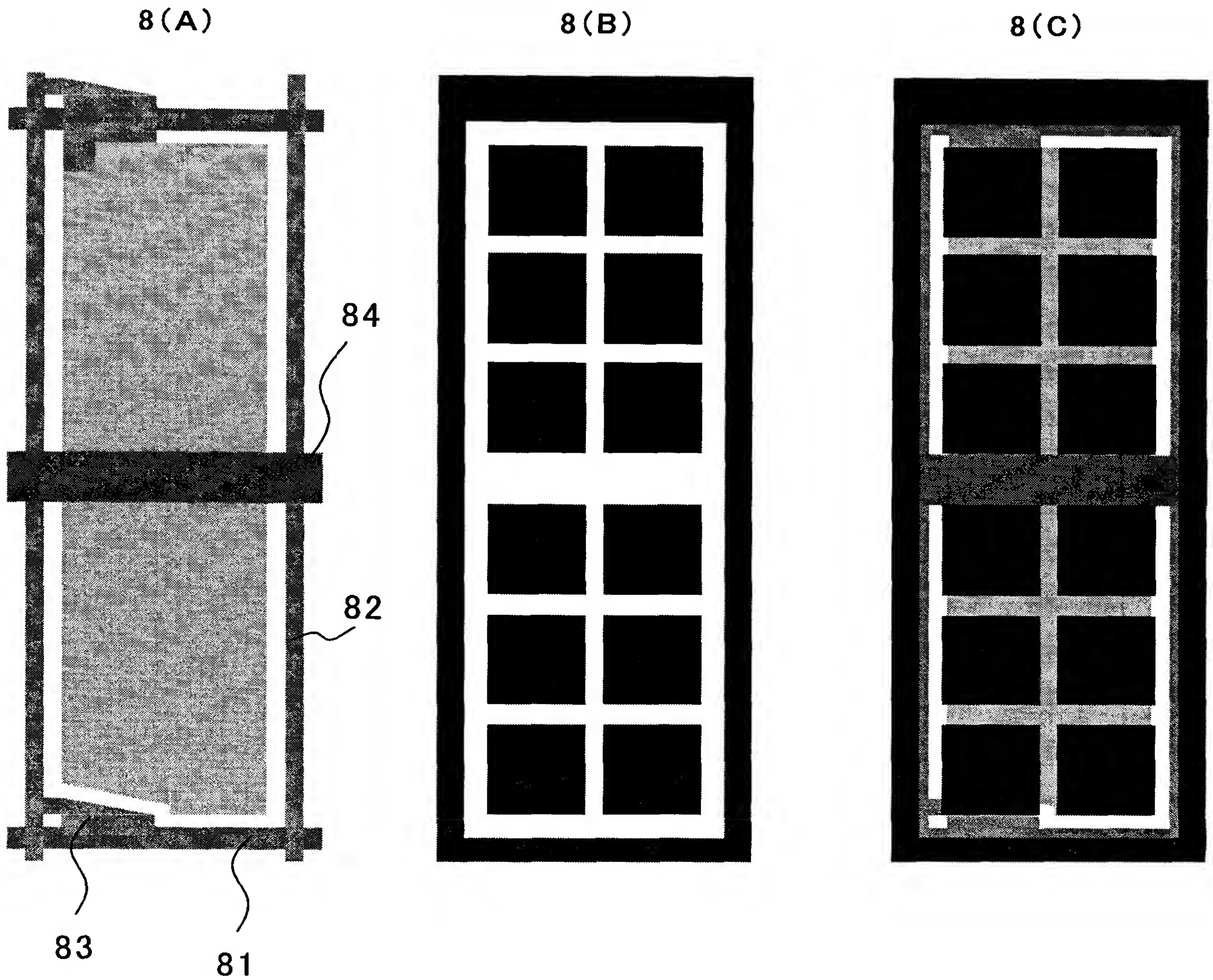
【FIG. 6】



【FIG. 7】

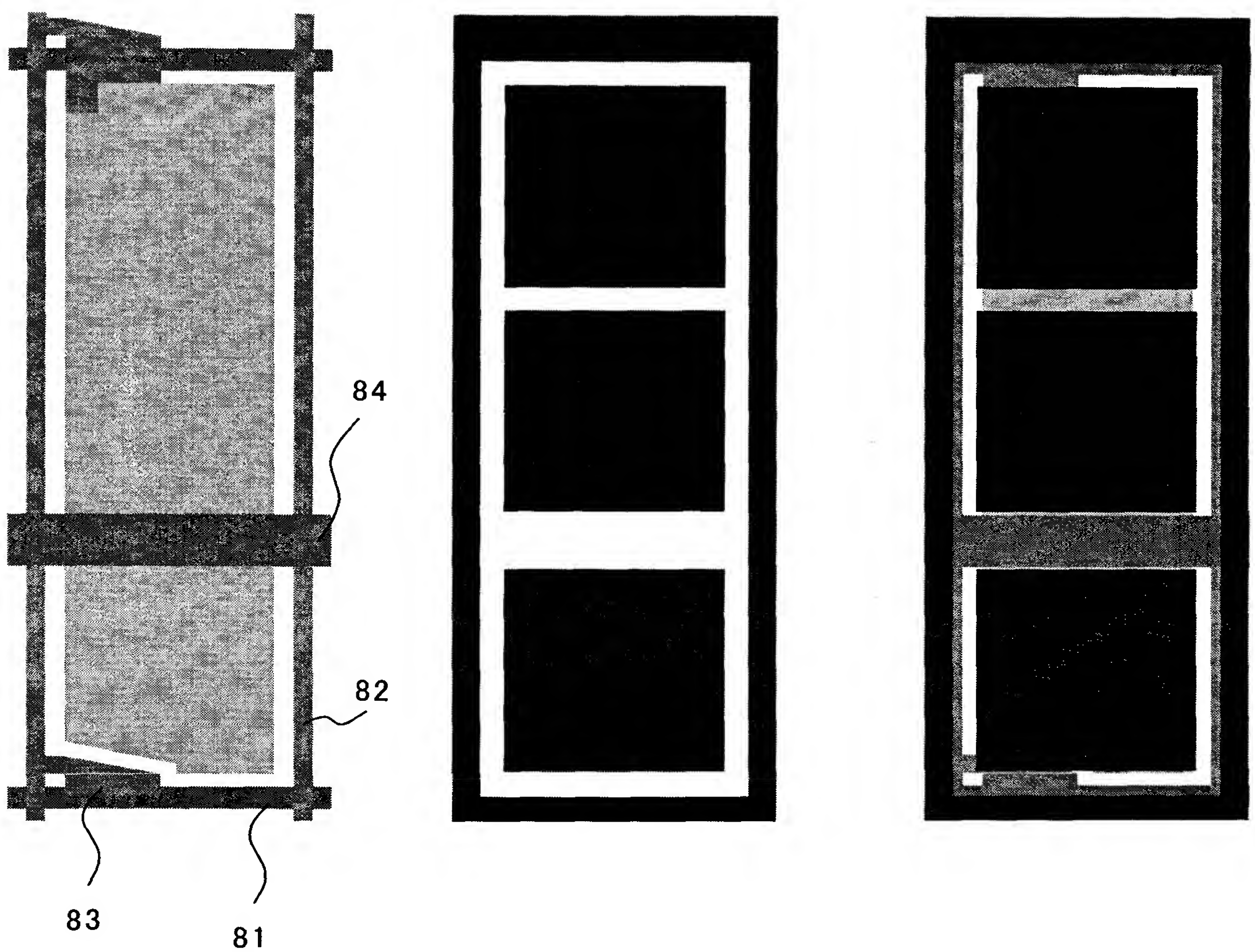

ABSORPTION AXIS
73
PHASE DELAY AXIS
74
22
23
21
PHASE DELAY AXIS
72
ABSORPTION AXIS
71

【FIG. 8】



【FIG. 9】

9(A) 9(B) 9(C)



【FIG. 10】